

# **2016 Landed Mission**

## ***Concepts & Possibilities***

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*September 18, 2008*



- ❑ Review the science discoveries that motivated the “existence proof” of the 2016 rover mission put forward by the Mars Strategic Science SAG and treated as a building block in the MATT-2 study
  - Recent discoveries
  - Lessons learned from MER operations
  - Findings of the ND-SAG which defined “minimum” requirements for a sample return cache
- ❑ Review (briefly!) some of the technical concept studies which illustrate emerging technical issues and capabilities
- ❑ This is background to a discussion of what a MEPAG SAG might do to further define a mission for the 2016 launch opportunity



Option	2016	2018	2020 <sup>#2</sup>	2022 <sup>#2</sup>	2024	2026	Comments
2018a <sup>#1</sup>	MSR-O	MSR-L	MSO	NET	Scout	MPR	Funded if major discovery?
2018b <sup>#1</sup>	MSO	MSR-L	MSR-O	NET	Scout	MPR	Restarts climate record; trace gases
2018c <sup>#1</sup>	MPR	MSR-L	MSR-O	MSO	NET	Scout	Gap in climate record; telecom?
2020a	MPR	MSO	MSR-L	MSR-O	NET	Scout	MPR helps optimize MSR
2020b	MPR	Scout	MSR-L	MSR-O	MSO	NET	Gap in climate record, early Scout
2022a	MPR	MSO	NET	MSR-L	MSR-O	Scout	Early NET; MPR helps MSR
2022b	MSO	MPR	NET	MSR-L	MSR-O	Scout	Early NET, but 8 years between major landers (MSL to MPR)
2024a	MPR	MSO	NET	Scout	MSR-L	MSR-O	Early NET; 8 years between major landers; very late sample return

MSO = Mars Science Orbiter

MPR = Mars Science Prospector (MER or MSL class Rover with precision landing and sampling/caching capability)

MSR = Mars Sample Return Orbiter (MSR-O) and Lander/Rover/MAV (MSR-L)

NET = Mars Network Landers ("Netlander") mission

#### FOOTNOTES:

#1 Requires early peak funding well above the guidelines; 2018b most affordable of these options

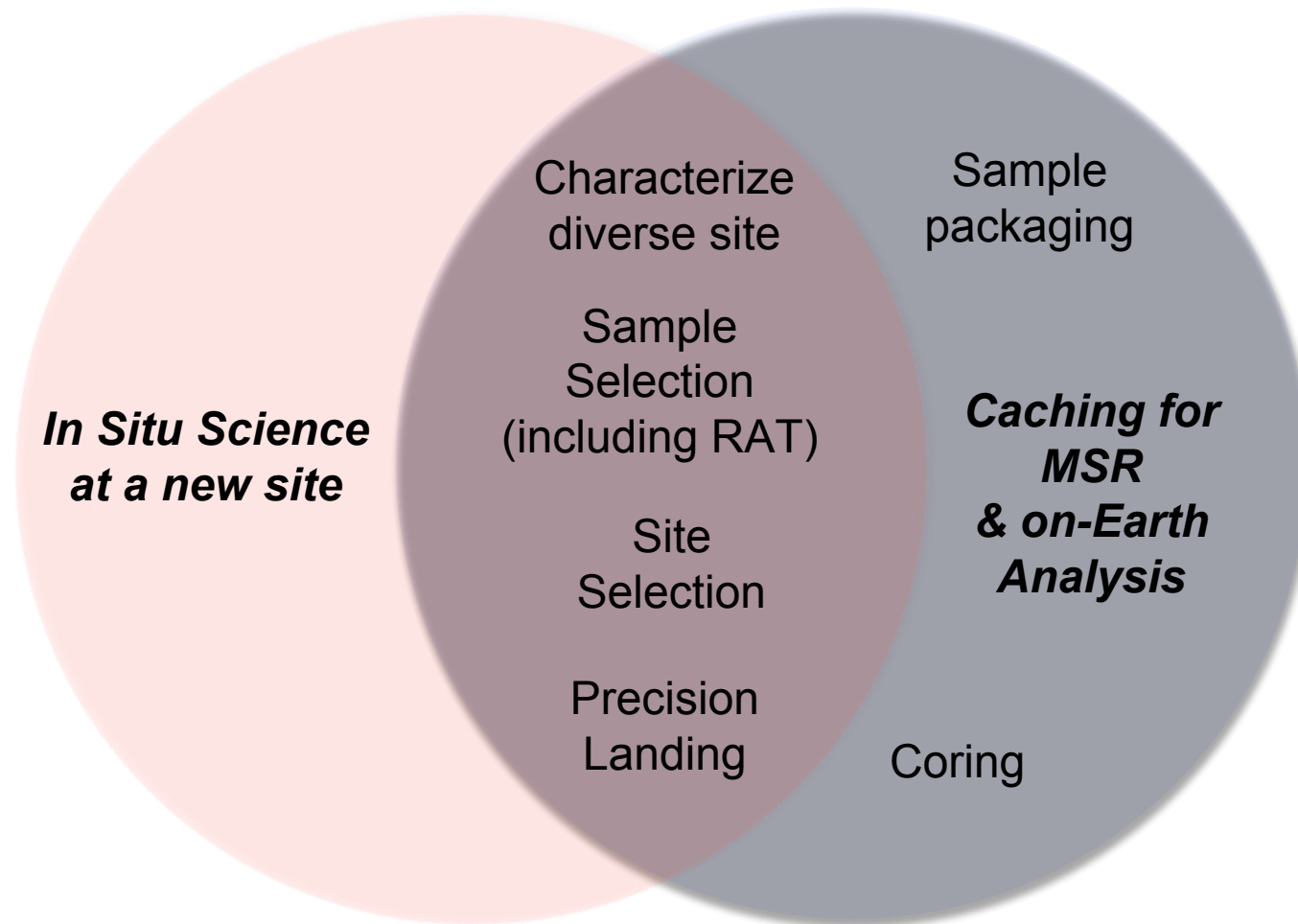
#2 Celestial mechanics are most demanding in the 2020 and 2022 launch opportunities; arrival conditions (Mars atmospheric pressure, dust opacity) challenging after 2020

*Preferred Scenario for given MSR-L Launch Opportunity*





- ❑ **From MATT-2: Launch at least a MER-class rover to a new site**
  - MER-class does not mean a MER clone, but is an indicator of lander capability in terms of mass, power, range and payload capability.
- ❑ **Mission as envisioned by MATT-2 has a dual science role:**
  - Stand-alone science conducted *in situ* at a new site
  - Preparation of a sample cache meeting the requirements for a sample return mission (addressing both geochemical and astrobiological science questions-- *Astrobiology Strategy report; ND-SAG*)
- ❑ **Technologies envisioned:**
  - Precision landing (~ 3km ellipse radius), which is desired for both science roles
  - Coring is required for sample return; “ratting” is required for *in situ* science
  - Sample encapsulation/preparation is required for sample return
- ❑ **Programmatic Considerations:**
  - Funding is tight for a 2016 mission
  - A 2016 mission must be justifiable on the basis of its *in situ* science alone
  - A 2016 landed mission should provide critical feed-forward to a possible MSR
  - A rover mission in 2016 would help preserve the ability (e.g., EDL expertise) to do major landed missions on Mars, including MSR
  - Ready to go beyond a “Follow the Water” theme to something new: Exploring habitable environments within the context of understanding Mars as a system



# MEPAG MSS-SAG: Discoveries of New Terranes



*Recent orbital observations (MGS, ODY, MEX, MRO) have revealed  $\geq 8$  terrane types with distinctive aqueous mineralogy, structure & stratigraphy*

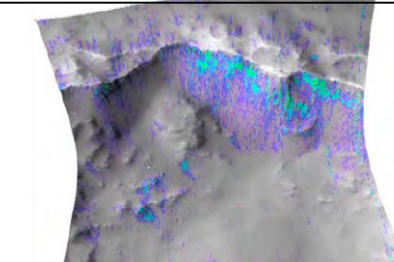
Noachian layered clays (type: Mawrth Vallis)



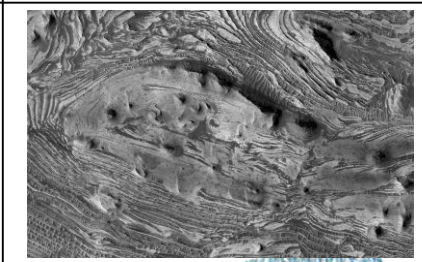
Noachian Meridiani-type layered deposits (type: Terra Meridiani)\*\*\*



Deep Noachian phyllosilicates exposed in highland craters, chasma walls (type: Tyrrhena Terra)



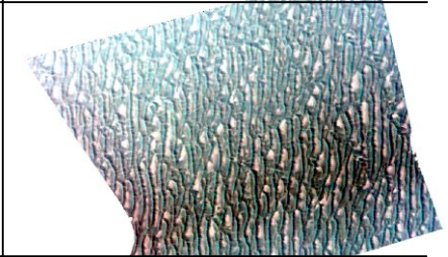
Hesperian Valles-type layered deposits (type: Candor Chasma)



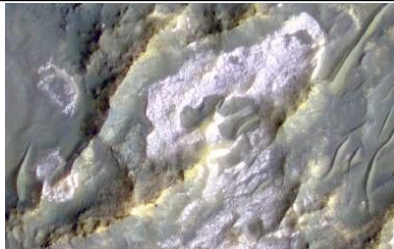
Noachian intra-crater fans with phyllosilicate-rich layers (type: Jezero Crater)



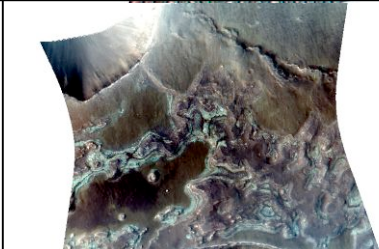
Amazonian gypsum deposits (type: Olympia Undae)

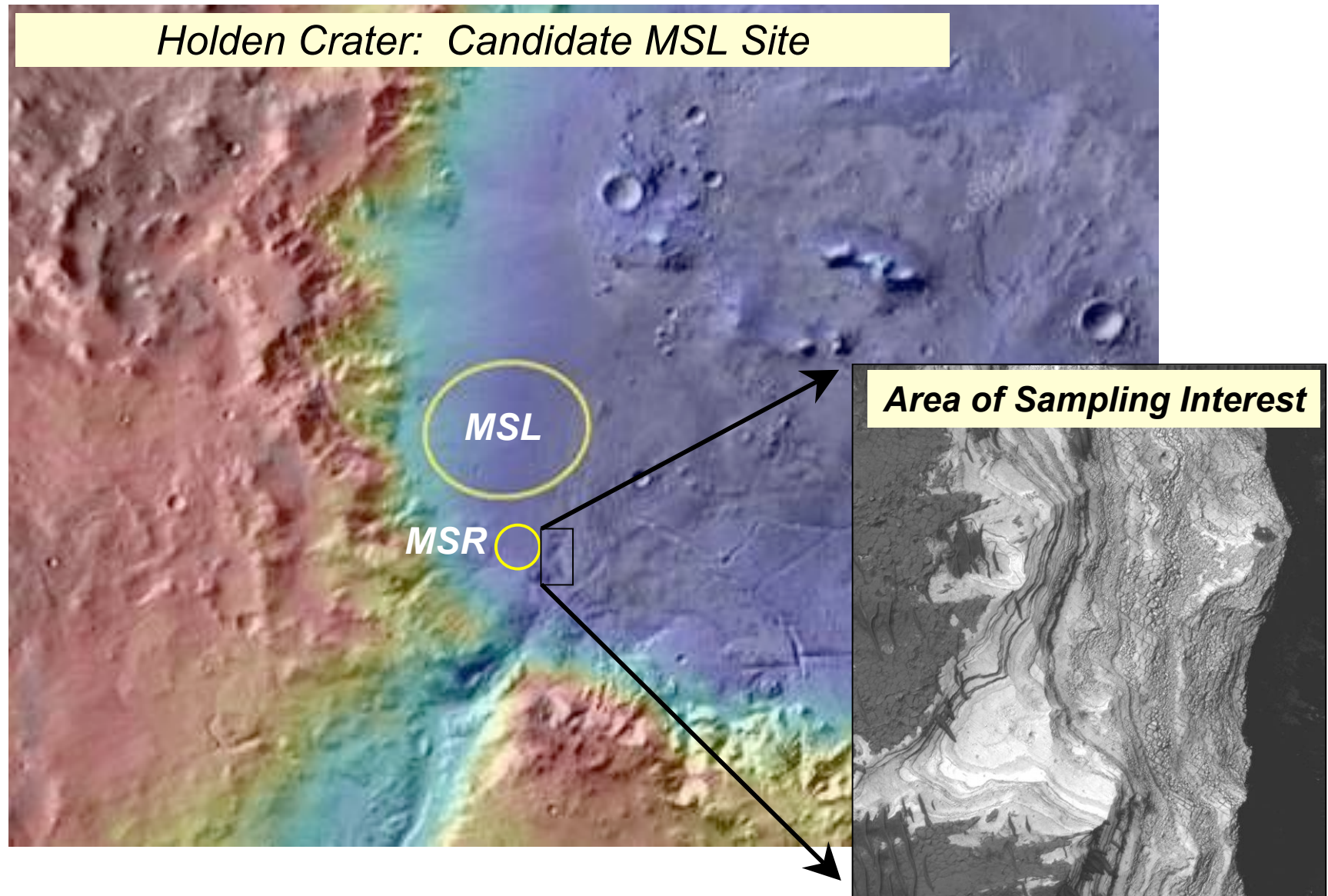


Noachian chloride salt deposits (type: Terra Sirenum)

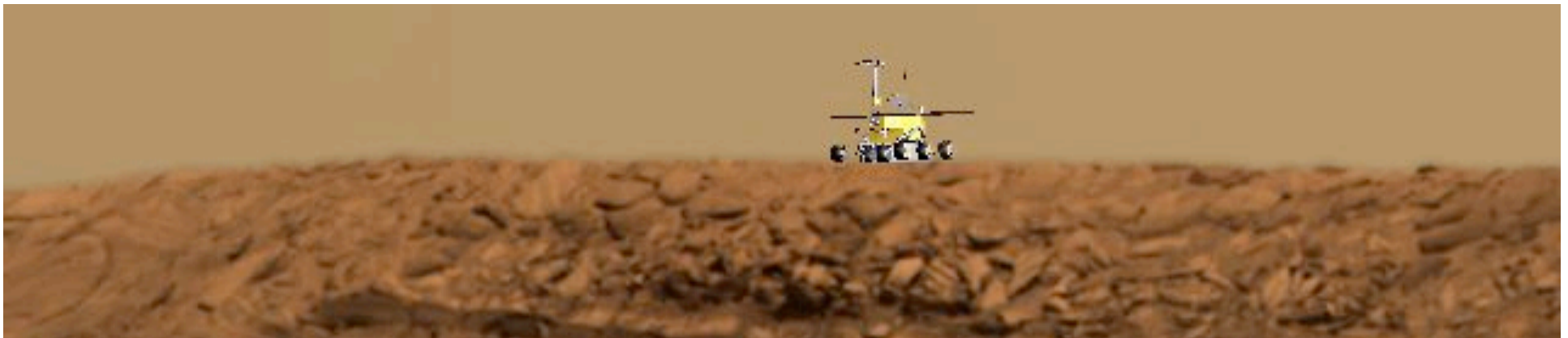


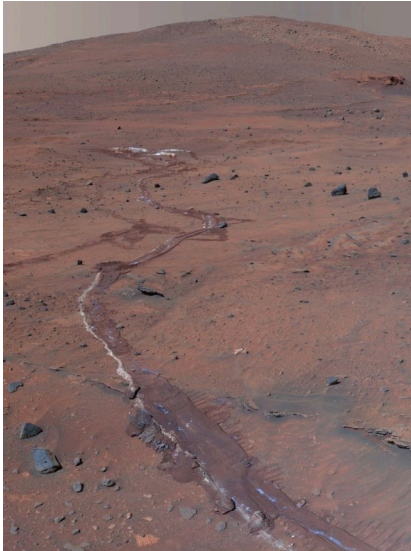
Thin Hesperian layered deposits with hydrated silica (type: Ophir Planum)





- ❑ **Opportunity investigated the first orbital detection of a possible aqueous mineral - gray hematite**
- ❑ **Possible genetic mechanisms (from original TES discovery)**
  1. Sedimentation from surface waters.
  2. Precipitation from hydrothermal fluids
  3. Alteration of basalts
- ❑ ***In situ* measurements were essential to interpreting origin**
  - None of the original hypotheses was correct
  - #1 was closest (diagenesis of eolian sediments by groundwater, deposition and reworking by surface waters)
- ❑ **6 technical capabilities proved essential (next slide)**

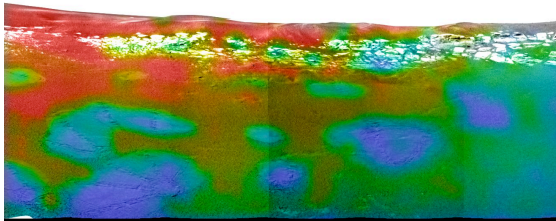




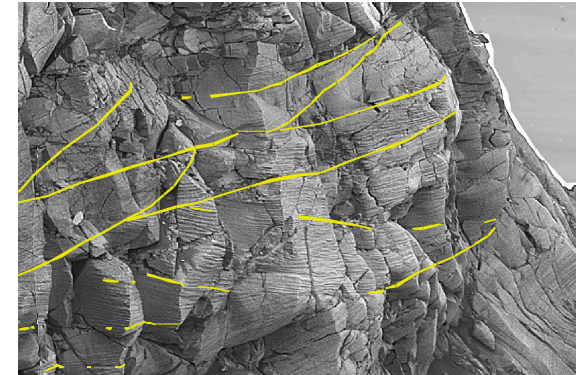
1. Accessibility (precision landing + mobility) is critical to reach deposits of interest. Crossing a contact during an extended mission is like landing at two sites.

2. Panoramic imaging with sufficient resolution detects geologic units & characterizes structures

3. Spectral mapping shows mineral distribution and relates it to imaging results, to identify key sites for contact measurements

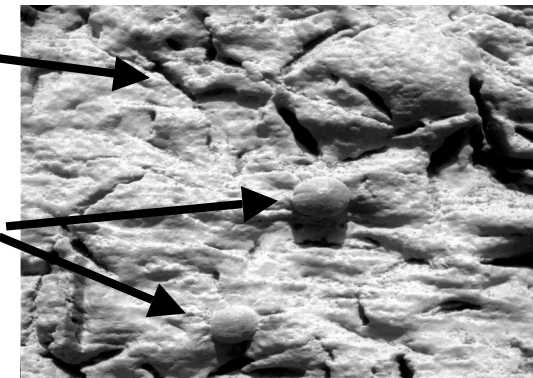


4. Microscopic imaging reveals textures needed to understand lithologies



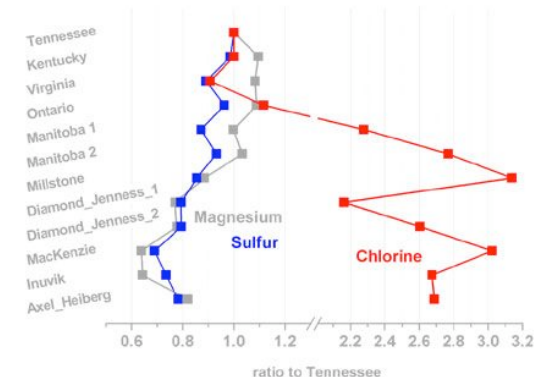
Crystal Mold

Spherules



5. An abrasion tool provides fresh surfaces for accurate elemental composition measurements

6. Elemental composition data show geochemical trends needed to understand depositional and alteration environments



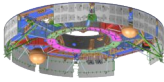
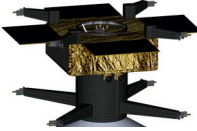
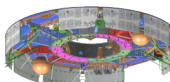
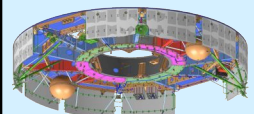
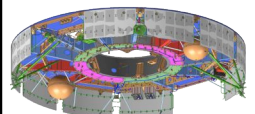
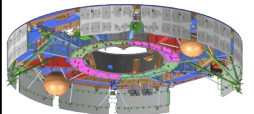
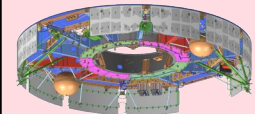
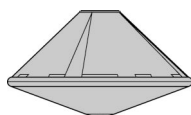
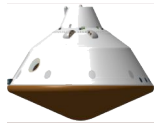
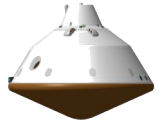
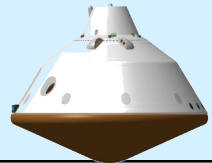
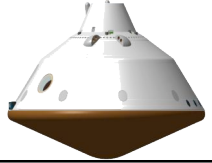
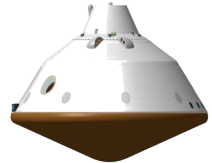
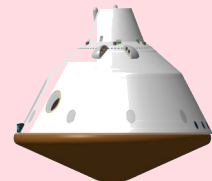
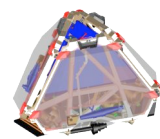
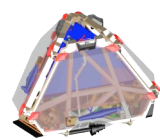
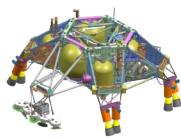
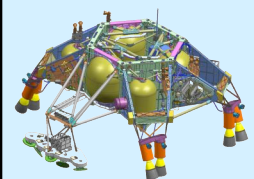
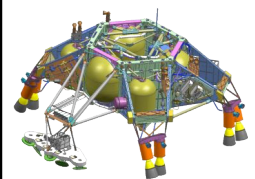
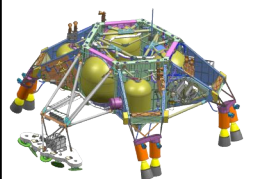
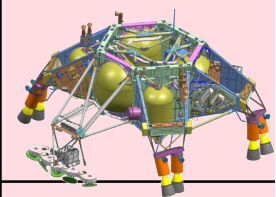
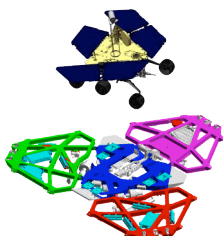
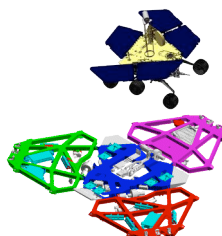
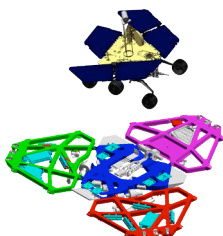
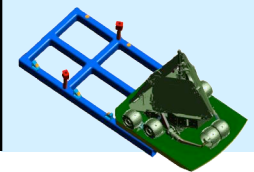

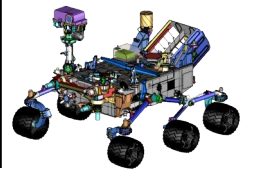
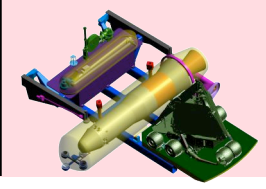


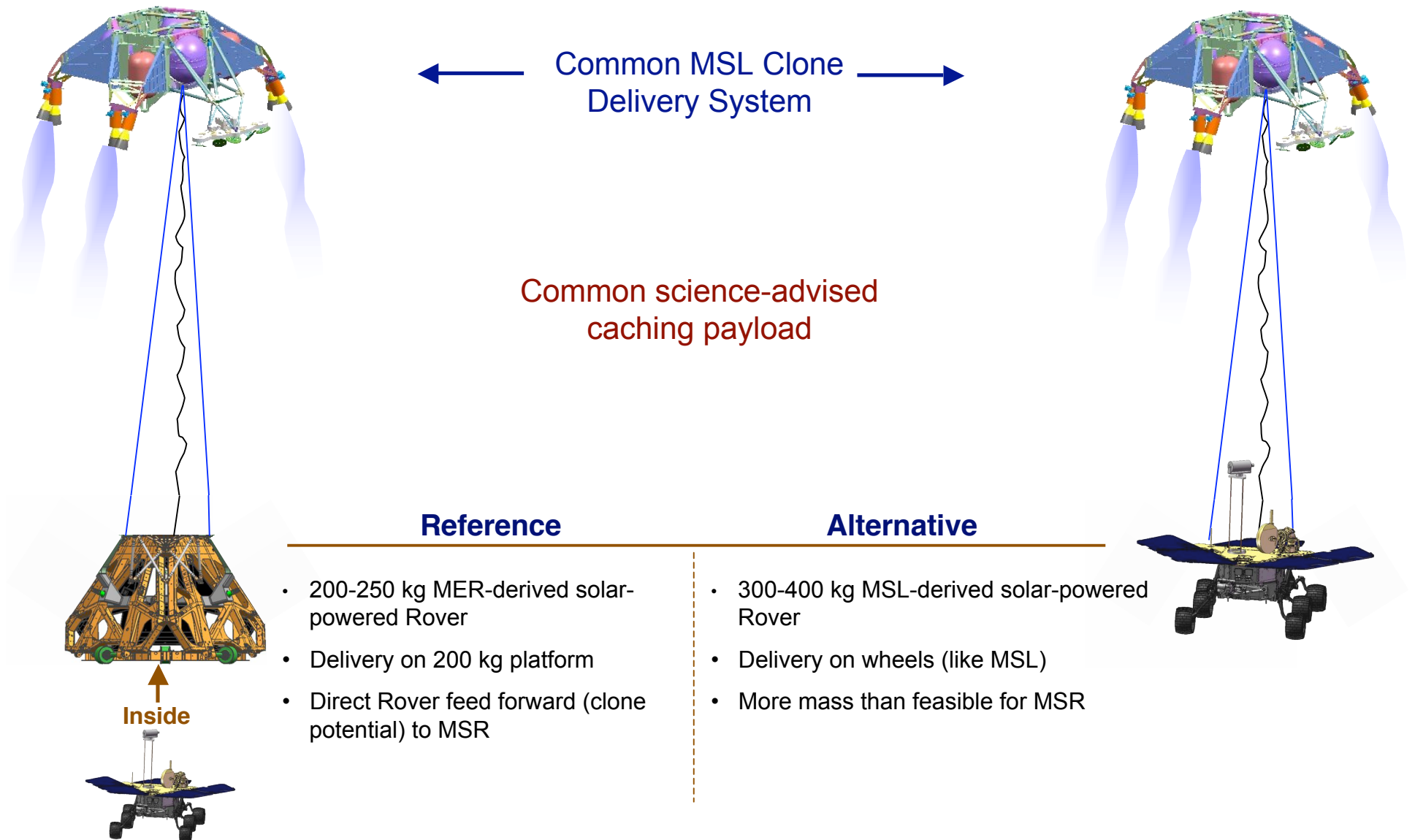
What is the minimum number of measurement types necessary to make effective sample selection decisions and to document the context of the samples collected?

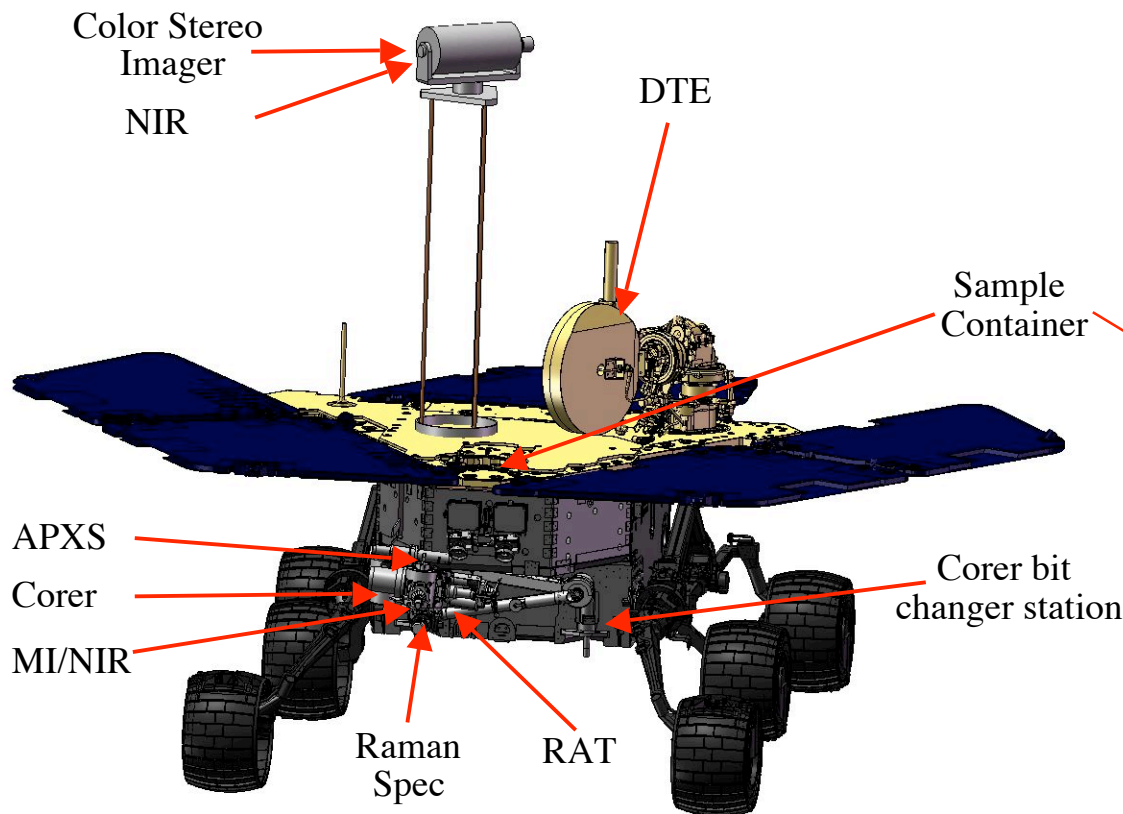
**Case A:** New site (capabilities assumed by MATT for 2016 rover)

**Case B:** Revisit previously characterized site for SR

What is needed	Suggested measurement	Case A	Case B
Ability to locate samples	Color stereo imagery	YES	YES
Ability to determine fine rock textures (grain size, crystal morphology), detailed context	Microscopic imagery	YES	YES
Ability to differentiate rock types, effects of different natural processes	Mineralogy	YES	NO
Ability to differentiate rock types, effects of different natural processes	Bulk Elemental abundance	YES	NO
Ability to detect organic carbon	Organic carbon detection	YES	NO
Ability to remove weathered or dust-coated surface and see unweathered rock	Abrasion tool	YES	NO

Case 0	Case 1	Case 2	Case 3 Reference	Case 6	Case 5	MSR
<i>MER-Clone &amp; Unguided MER-Based EDL</i>	<i>MER-Based Rover Guided MER-Based EDL</i>	<i>MER-Based Rover &amp; MSL-Scaled EDL</i>	<i>MER-Based Rover &amp; MSL-Based EDL</i>	<i>MER/MSL Hybrid Rover &amp; MSL-Based EDL</i>	<i>MSL-Based Rover (RTG) &amp; MSL-Based EDL</i>	<i>MSR-Lander &amp; MSL-Scaled EDL</i>
						
						
						
						

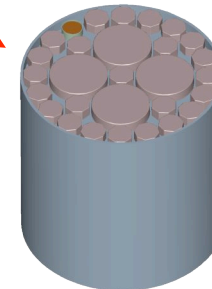




**Payload Mass ~ 42 kg**  
**Rover Mass ~200 – 250 kg**

### Capabilities / Scope

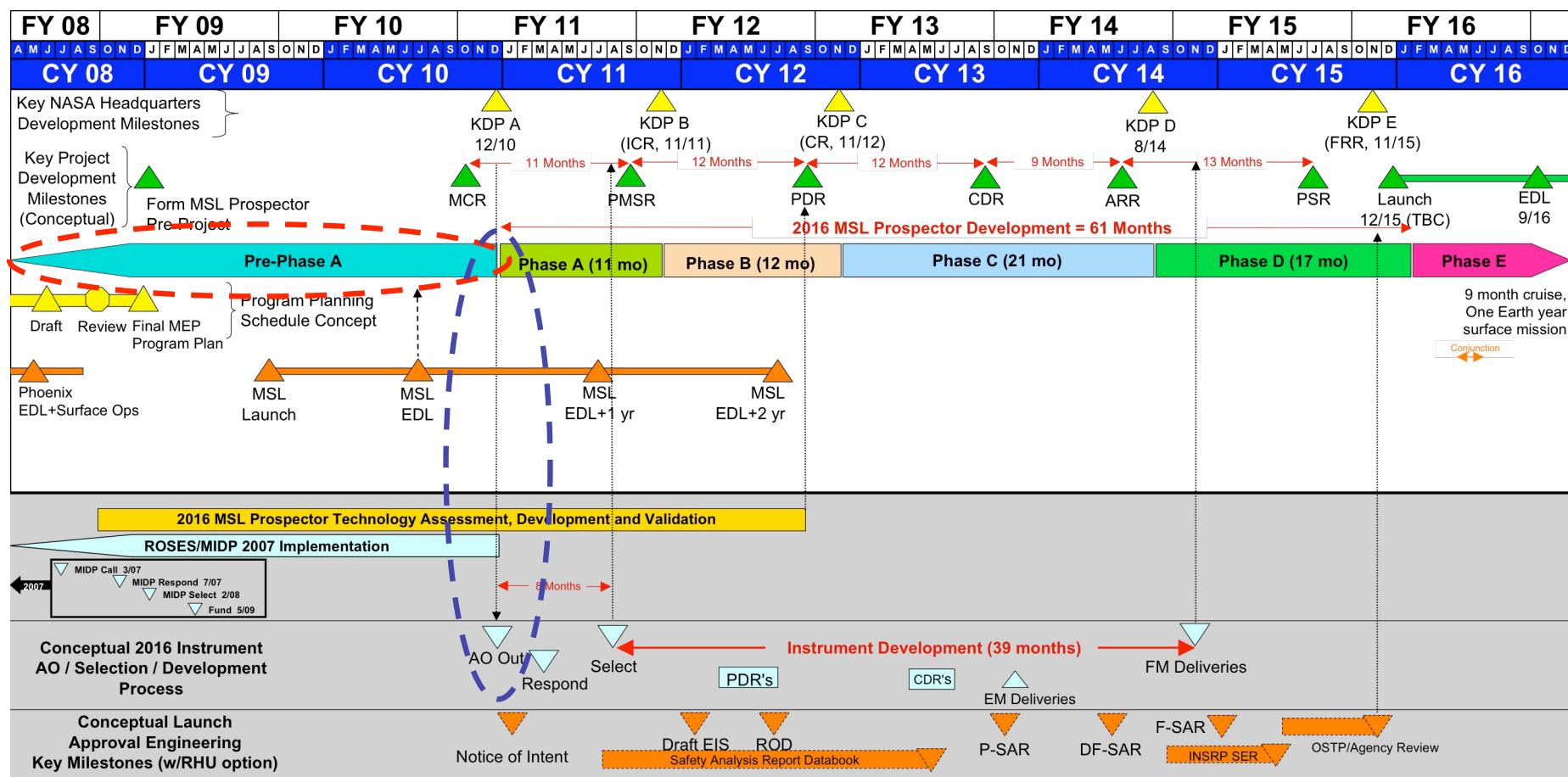
- 20 Cores
- Multiple coring suites (4)
- Multiple regolith samples (3)
- Payload for sample selection (MER-like; ND-SAG)
- ~1 year collection time



Category	MER (as built)	2016 Rover Point-Design
Science Instruments	4.5 kg	11 kg (4.3 kg C detector)
Science Support	15.7 kg	31 kg
Mast	10.4 kg	3.2 kg
Arm (with turret)	4.6 kg	11.7 kg
RAT	0.7 kg	0.6 kg
Corer + bit changer	n.a.	7.8 kg
Sample encapsulation & cache	n.a.	5.2 kg
Bio-barrier	n.a.	2.6 kg
Command & Data	12 kg	21 kg
Power	18 kg	34 kg
Structures & Mechanisms	100 kg	143 kg
<b>Rover Total</b>	<b>174 kg</b>	<b>250 kg</b>



## 5-Year Development





### ❑ Science Goals

- What should be the science of a 2016 mission?
- MATT-2 (& MSS-SAG before it) advocated going to a new site known to have had aqueous activity (from orbital data) but different from terranes sampled *in situ* already
- *In situ* science would characterize the geologic history of the site, the role of water, and the potential for habitability
- Should there be additional goals or a different balance of goals?
  - Implications for *in situ* science instruments, site selection and rover capabilities

### ❑ Site Selection

- What are the site requirements for the mission's *in situ* science and also for sample return science?
  - What are the precision landing requirements needed to get there?
  - How best to use existing orbital assets (ODY, MEX, MRO) to identify such sites?

### ❑ Technology Feed-Forward

- How much feed-forward to MSR should be built into a 2016 mission
  - Should one put the 2016 mission on the critical path to MSR (i.e., MSR has only a fetch rover)?
  - Or do we always plan that MSR will always have its own sample-caching rover?
    - Should the 2016 rover be “clone-able” for inclusion on the MSR lander?
- How does one maintain the dual-purpose of the mission?
  - Is coring a capability that should be required for the *in situ* site science?
  - Planetary Protection: How much should be attempted on this mission?



Goal	Objective	Priority	Investigation	2010	2013-2016			2018-2020
				MSL	MSO (atmospheric)	Network	Mid-range Rover	MSR (assuming non-polar site)
III. GEOLOGY/GEOPHYSICS	A. Crust	HIGH ↓ LOW	1 PRESENT STATE AND CYCLING OF WATER					
			2 SEDIMENTARY PROCESSES AND EVOLUTION					
			3 CALIBRATE CRATERING					
			4 IGNEOUS PROCESSES AND EVOLUTION					
			5 SURFACE-ATM INTERACTIONS					
			6 LARGE-SCALE CRUSTAL VERT STRUCTURE					
			7 TECTONIC HISTORY OF CRUST					
			8 HYDROTHERMAL PROCESSES					
			9 REGOLITH FORMATION AND MODIFICATION					
			10 CRUSTAL MAGNETIZATION					
			11 EFFECTS OF IMPACTS					
IV. PREPARATION	B. Interior	HIGH ↓ LOW	1 STRUCTURE AND DYNAMICS OF INTERIOR					
			2 ORIGIN AND HISTORY OF MAGNETIC FIELD					
			3 CHEMICAL AND THERMAL EVOLUTION					
			4 PHOBOS/DEIMOS					
	A: Science Measurements	HIGH ↓ LOW	1 DUST - ENGINEERING EFFECTS					
			2 ATMOSPHERE (EDL/TAO)					
			3 BIOHAZARDS					
			4 ISRU WATER					
			5 DUST TOXICITY					
			6 ATMOSPHERIC ELECTRICITY					
			7 FORWARD PLANETARY PROTECTION					
			8 RADIATION					
			9 SURFACE TRAFFICABILITY					
			10 DUST STORM METEOROLOGY					
	B: Eng/TI Demos	↓ LOW	1 AEROCAPTURE					
			2 ISRU DEMOS					
			3 PINPOINT LANDING					
			4 TELECOM INFRASTRUCTURE					
			5 MATERIALS DEGRADATION					
			6 APPROACH NAVIGATION					

## LEGEND

Major contribution

Significant contribution

2013-2016 investigations not addressed by MSR  
lander

Potential to extend *in situ*  
observation to classes of deposits  
not investigated previously



Goal	Objective	Priority	Investigation	2010	2013-2016			2018-2020
				MSL	MSO (atmospheric)	Network	Mid-range Rover	MSR (assuming non-polar site)
I. LIFE	A: Habitability	HIGH	1 CURRENT DISTRIBUTION OF WATER					
			2 GEOLOGIC H <sub>2</sub> O HISTORY					
		LOW	3 C,H,O,N,P, AND S - PHASES					
			4 POTENTIAL ENERGY SOURCES					
	B: Carbon	HIGH	1 ORGANIC CARBON					
			2 INORGANIC CARBON					
		LOW	3 LINKS BETWEEN C AND H, O, N, P, S					
			4 REDUCED COMPOUNDS ON NEAR SURFACE					
	C: Life	HIGH	1 COMPLEX ORGANICS					
			2 CHEMICAL AND/OR ISOTOPIC SIGNATURES					
		LOW	3 MINEROLOGICAL SIGNATURES					
			4 CHEMICAL VARIATIONS REQUIRING LIFE					
II. CLIMATE	A. Present	HIGH	1 WATER, CO <sub>2</sub> , AND DUST PROCESSES					
			2 SEARCH FOR MICROCLIMATES					
		LOW	3 PHOTOCHEMICAL SPECIES					
	B. Ancient	HIGH	1 ISOTOPIC, NOBLE & TRACE GAS COMP.					
			2 RATES OF ESCAPE OF KEY SPECIES					
		LOW	3 ISOTOPIC, NOBLE, AND TRACE GAS EVOLUTION					
			4 PHYS AND CHEM RECORDS					
			5 STRATIGRAPHIC RECORD--PLD					
	C. Safe s/c ops	HIGH	1 THERMAL & DYNAMICAL BEHAVIOR OF PBL					
			2 ATM. BEHAVIOR 0-80 KM					
		LOW	3 ATM. MD 80-200 KM					
			4 ATM. MD >200 KM					

## LEGEND

Major contribution

Significant contribution

2013-2016 investigations not addressed by MSR lander

Potential to extend *in situ* observation to classes of deposits not investigated previously